Maryland Biological Stream Survey
2000-2004

Volume 8:
County Results

Prepared for

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FOREWORD

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ABSTRACT

One of the most important potential uses of the Maryland Biological Stream Survey (MBSS) is at the local level, by citizens and county governments. Recognizing this importance, this volume assessing 2000-2004 MBSS data was prepared to highlight survey results in a form most useable by local governments. Among all counties in Maryland, Queens Anne's County had the highest Combined Biotic Index (CBI) score (3.49), with an overall stream health rating of Fair. Other counties in the top five included Charles, Carroll, St. Mary's, and Talbot. In contrast, Baltimore City had the lowest average CBI (2.18), with an overall stream integrity rating of Poor. The next lowest counties were Somerset, Dorchester, Anne Arundel, and Washington. Charles and Prince George's counties shared the highest rated watershed for freshwater biodiversity (Zekiah Swamp), while Frederick County's Catoctin Creek watershed was the lowest ranked watershed for freshwater biodiversity in any county. Counties with low dissolved oxygen (DO) levels included: Somerset (38% of stream miles), Dorchester (26%), Caroline (26%), Baltimore City, and Talbot (23%). Caroline County had the highest mean nitrate-nitrogen levels (5.51 mg/l), followed by Dorchester County (4.59 mg/l); the lowest county mean was observed in Somerset County (0.40 mg/l). There was a strong relationship between mean nitrate-nitrogen levels for each county and the percentage of that county harvested as cropland. Allegany (0.010 mg/l) and Garrett Counties (0.013 mg/l) had the lowest mean levels of Total Phosphorous, while Worcester (0.125 mg/l) and Kent (0.117 mg/l) had the highest mean levels. The total number of chickens in a county was significantly related to the mean Total Phosphorous concentration in that county. Allegheny and Garrett Counties had the highest mean Physical Habitat Index score (77 on a 100 point scale), while Baltimore City (50/100) and Cecil County (63/100) had the lowest mean habitat values. Urban counties had poorer trash rating scores than agricultural counties. Baltimore City received the lowest mean rating (5 on a 20 point scale), followed by Prince George's, Anne Arundel, and Baltimore County. The least amount of human refuse on average along or in streams was found in Garrett (18/20) and Queen Annes Counties (17/20). Among all counties, Washington had the highest estimate of stream miles with no riparian buffer (20%), followed by Wicomico (19%), Cecil (11%) and Frederick (11%). The counties with the highest occurrence of riparian buffer breaks were Baltimore City (44%), Wicomico (19%), Worcester (15%), and Baltimore County (15%). From these analyses, it is clear that buffer breaks are a potentially important limitation to the effectiveness of riparian buffers in Maryland. The information contained here should help policymakers, planners, and others justify and guide natural resource conservation and restoration efforts in Maryland. In addition, the findings presented here may help guide other restoration efforts into the most needed areas, especially those associated with the Chesapeake Bay.

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8.1 INTRODUCTION

This report volume about stream conditions in Maryland's counties is part of a series of documents that details findings of the Maryland Biological Stream Survey (MBSS, or the Survey). It is particularly important because local-scale land planning decisions have a pronounced effect on stream and watershed conditions. Most volumes in the series use data from the 2000-2004 Survey. However, some documents, including this volume, utilize data from 1994 to 2004 and incorporate data from other sources as well.

The audience for this volume includes all those who have an interest in stream and watershed conditions in their county. The information contained here should help policymakers, planners, and others justify and guide natural resource conservation and restoration efforts in Maryland. In addition, the findings presented here may help guide other restoration efforts into the most needed areas, especially those associated with the Chesapeake Bay. In the interest of brevity, only select variables are presented in this volume, but county estimates can be calculated for all variables measured by the MBSS. In the interest of clarity, a **Glossary** of selected terms is provided at the back of this volume.

DATA FOR THIS REPORT:

A number of data sources were utilized for this volume, including data from the core MBSS program, county data that were submitted in response to our solicitation, and data from the volunteer component of MBSS, Stream Waders. The probability-based design of the core MBSS allowed for estimation of various aspects of condition with a known degree of confidence. County data augmented these findings, and Stream Waders data helped fill in gaps where no MBSS samples were collected. The next revision of this report will incorporate County data to a greater extent.

Every type of data collection has limitations and advantages, and the data used here are no exception. For all monitoring programs, sample size determines what can be concluded about a given geographic area, and the demand for information is often at a scale finer than can be accommodated by available data. Even with a minimum of ten sites in a watershed, confidence intervals about the estimates of condition are often quite high. One limitation more specific to MBSS data is that water chemistry samples are collected at a single point in time and in some cases may not capture the prevailing conditions at the site. In general, however, strong, consistent relationships between variables such as nitrate-nitrogen and percent agriculture in the upstream catchment confirm that the MBSS method of data collection does have utility. Another limitation of the MBSS is that subtle trends in condition in small geographic areas are difficult to detect because only Sentinel sites are revisited each year. However, if improvements in condition occur across larger areas, these trends will likely be detected by the MBSS.

One limitation of Stream Waders data is the uncertainty about whether samples were collected properly by volunteers, whether the correct coordinates and site information was recorded, etc. However, Quality Control visits and duplicate sampling by professionals have repeatedly demonstrated that Stream Waders data is of generally high quality. An additional limitation is that non-randomly selected sites are not generally useful for condition estimates. A major advantage of Stream Waders data is high spatial density. Because of this density, at least general statements can be made about the condition of many small watersheds that were never sampled before.

Finally, there are limitations with direct incorporation of data collected by county agencies, because no such agency has a sampling design identical to the core MBSS. The difficulties of incorporation are formidable and costly, but do enhance the ability of counties to draw conclusions from the data.

WHO CAN USE THIS DOCUMENT:

Citizens and Local Environmental Groups - to better understand and provide input on conservation and restoration initiatives

Landowners - to make informed decisions about long-term conservation and restoration on their property

Local Governments - to incorporate sound, targeted conservation practices, policies, and zoning

Educational Institutions - to provide a conservation education tool for use by students in each county

This volume contains a chapter summarizing conditions in all counties, followed by a chapter for each individual county and one for Baltimore City. Other volumes in this series also contain information that may be of use to the reader, especially the volumes on biodiversity (Volume 12) and riparian buffers (Volume 10). To limit the size and complexity of this volume and increase readability, all methods used to prepare and analyze data for this volume are presented in: 2000-2004 Maryland Biological Stream Survey Laboratory, Field, and Analytical Methods: Volume 6. This volume and others can be downloaded from http://www.dnr.Maryland.gov/streams/pubs/.

8.2 COUNTY COMPARISONS

8.2.1 Biotic Integrity

The Combined Biotic Index (CBI) was developed to provide a single measure of stream health for Maryland streams. The CBI is derived from the Fish Index of Biotic Integrity (FIBI) and the benthic macroinvertebrate Index of Biotic Integrity (BIBI). Among all counties in Maryland during 2000-2004, Queen Anne's County had the highest Combined Biotic Index (CBI) score (3.49), with an overall rating of Fair (Table 8-1). Other counties in the top five included Charles, Carroll, St. Mary's, and Talbot. In contrast, Baltimore City had the lowest average CBI (2.18), with an overall stream integrity rating of Poor. The next lowest counties were Somerset, Dorchester, Anne Arundel, and Washington.

For the Fish Index of Biotic Integrity (FIBI), Carroll County had the highest mean score (3.62), with an overall rating of Fair (Table 8-1). The next highest four counties were Howard, Queen Anne's, Cecil, and Kent County. Caroline County had the lowest mean FIBI score (2.23), followed by Calvert, Baltimore City, Dorchester, and Anne Arundel. Overall, 13 counties and Baltimore City had an average FIBI rating of Poor, ten counties rated Fair, and no county had a mean FIBI score in the Good range.

The overall results for the Benthic Index of Biotic Integrity (BIBI) were generally similar to the FIBI. Fourteen counties rated in the fair category, ten counties and Baltimore City were rated in the Poor category (Table 8-1). Among individual counties, St. Mary's County had the highest mean BIBI score, and Baltimore City had the lowest mean score. Interestingly, the highest four counties for mean BIBI (Charles, Talbot, St. Mary's, and Queen Anne's) are all located in the Coastal Plain region.

In general, urban or urbanizing counties had higher scores for fish than for benthic macroinvertebrates. A possible explanation for this phenomenon is that fish are more mobile than benthos, and thus better able to move to refugia during adverse conditions such as high flows during summer thunderstorms. In contrast, mean scores for fish in Calvert and Anne Arundel Counties were considerably lower than mean benthic scores. The networks of many streams in these counties are relatively small and isolated from recolonization by fish because of the salinity in Chesapeake Bay. Thus, historical problems of a watershed-wide nature (e.g., clearcutting) could result in elimination of some fish species because there was no chance for recolonization. In contrast, at least some benthic macroinvertebrates are capable of movement to neighboring watersheds (via flying as adults).

The BIBI and FIBI results presented in this report have been validated as being able to consistently distinguish between degraded and reference conditions (Southerland et al., 2005). However, like any tool, indices of biotic integrity may not perform at a uniform level throughout the range of conditions where they are used. In addition, different taxonomic groups may not respond in the same way to the myriad number of stressors to Maryland streams. Thus, some differences in ratings between assemblages should be expected.

8.2.2 Chemical Conditions

As described earlier, MBSS water chemistry data represent grab samples from a single point in time, and thus may not capture prevailing conditions at a site or seasonal/event driven changes. However, these data have been useful in describing overall patterns as well as illustrating specific water quality problems. For example, it is highly likely that if low dissolved oxygen levels are observed at a site on one occasion, low levels have been occurring at other times as well. Further, even short duration exposure to some conditions can profoundly alter the biological community.

IBI SCORES AND RATING TRANSLATION

The Index of Biotic Integrity, or IBI, was developed to help rate the health of streams, including their water quality. The IBIs developed for Maryland (see Southerland *et al*., 2005) are based on a series of reference sites that represent some of the best remaining stream habitats in the state. However, because most areas of Maryland have been subject to extensive human disturbance and there are no streams left that even approach pristine conditions, IBIs tend to overrate the actual quality of streams. To make it easier to interpret, numeric ratings are grouped into descriptive categories. In the MBSS, ratings are Good, Fair, Poor, and Very Poor. The lack of an Excellent rating is a recognition of the fact that the reference conditions used to develop the IBIs often have significant human perturbation associated with them.

8.2.2.1 Dissolved Oxygen

During the 2000-2004 MBSS, several Eastern Shore counties were observed to have a relatively high proportion of stream miles with dissolved oxygen (DO) problems. Although the Maryland regulatory criterion for low DO is 5 mg/l, 3 mg/l was used as the threshold for this report (a DO of 5 mg/l may be within the range of natural variability). Counties with low DO included: Somerset (38% of stream miles), Dorchester (26%), Caroline (26%), and Baltimore City (23%) (Table 8-2).

Table 8-1. Mean biological integrity scores for 4th order and smaller Maryland streams, by county, based on results from the 2000-2004 MBSS									
	Combined Biotic Index (CBI)			Fish Index of Biotic Integrity (FIBI)			Benthic Index of Biotic Integrity (BIBI)		
COUNTY	Mean	SE	Rank	Mean	SE	Rank	Mean	SE	Rank
Allegany	3.05	0.10	11	2.63	0.15	19	3.48	0.11	5
Anne Arundel	2.66	0.13	21	2.48	0.22	20	2.81	0.14	16
Baltimore	2.92	0.13	13	2.35	0.37	22	3.05	0.15	13
Baltimore City	2.18	0.28	24	2.76	0.17	18	2.12	0.07	24
Calvert	2.82	0.21	15	2.31	0.30	23	3.34	0.21	6
Caroline	2.80	0.17	16	2.23	0.20	24	3.22	0.17	11
Carroll	3.42	0.11	3	3.62	0.15	1	3.26	0.12	8
Cecil	3.33	0.18	7	3.43	0.20	4	3.25	0.21	9
Charles	3.43	0.11	2	3.03	0.15	10	3.83	0.12	2
Dorchester	2.54	0.19	22	2.42	0.34	21	2.61	0.22	21
Frederick	2.68	0.12	19	2.86	0.19	12	2.52	0.09	23
Garrett	3.08	0.11	10	2.85	0.12	14	3.33	0.12	7
Harford	3.19	0.08	8	3.28	0.13	8	3.18	0.09	12
Howard	3.34	0.09	6	3.45	0.13	2	3.23	0.14	10
Kent	3.17	0.15	9	3.41	0.21	5	3.00	0.16	14
Montgomery	2.89	0.10	14	3.16	0.16	9	2.65	0.09	19
Prince Georges	2.78	0.11	17	2.83	0.15	15	2.72	0.11	18
Queen Annes	3.49	0.20	1	3.44	0.24	3	3.50	0.21	4
Somerset	2.50	0.17	23	3.30	0.29	6	2.54	0.19	22
St Marys	3.40	0.11	4	2.86	0.15	13	3.89	0.13	1
Talbot	3.35	0.34	5	2.94	0.45	11	3.75	0.24	3
Washington	2.67	0.12	20	2.78	0.17	17	2.62	0.11	20
Wicomico	2.99	0.17	12	3.30	0.17	7	2.93	0.19	15
Worchester	2.72	0.19	18	2.82	0.29	16	2.78	0.21	17

Nine counties had no stream miles with very low DO conditions.

In the Coastal Plain region of Maryland, streams with high levels of dissolved organic carbon (DOC) tended to have low DO levels (Figure 8-1). Although the naturally poor light penetration in this tea-stained water is a likely contributing factor to the lower DO, many of the watersheds containing high DOC also have nutrient loads that are some of the highest in the state.

8.2.2.2 Nitrogen

Among all counties and Baltimore City, streams in Caroline County had the highest mean value for Total Nitrogen (6.24 mg/l), and Charles County streams had the lowest mean Total Nitrogen value (0.74 mg/l; Table 8-2). Caroline County also had the highest mean nitrate-nitrogen levels (5.51 mg/l), followed by Dorchester County (5.20 mg/l). The lowest nitrate-nitrogen level was observed in Somerset County streams (0.40 mg/l). There was a strong relationship between mean nitrate-nitrogen levels for each county and the percentage of that county harvested as cropland (Figure 8-2).

For ammonia, the county with the highest mean value was Kent County (0.22 mg/l), and the lowest levels were observed in Allegany and Garrett counties (0.01 mg/l).

8.2.2.3 Phosphorous

Anne Arundel (0.010 mg/l) and Garrett (0.013 mg/l) county streams had the lowest mean levels of Total Phosphorous observed during 2000-2004 (Table 8-2). In contrast, Worcester (0.125 mg/l) and Kent Counties (0.127 mg/l) had the highest mean levels in the state during 2000-2004. The total number of chickens reported for each county was significantly related to the mean Total Phosphorus concentrations in that county (Figure 8-3).

Table 8-2. Mean values for key chemical constituents of 4th order and smaller Maryland streams, by county, based on results from the 2000-2004 MBSS

	Total Nitrogen			Nitrate-N			Ammonia			Total Phosphorus			Dissolved Oxygen			pH			Acid Neutralizing Capacity (ANC)		
COUNTY	**Mean (mg/l)**	**SE**	**Rank**	**Mean (mg/l)**	**SE**	**Rank**	**Mean (mg/l)**	**SE**	**Rank**	**Mean (mg/l)**	**SE**	**Rank**	**% Stream miles < 3 mg/l**	**SE**	**Rank**	**Mean**	**SE**	**Rank**	**Mean (mg/l)**	**SE**	**Rank**
Allegany	0.75	0.06	2	0.65	0.06	6	0.01	0.00	1	0.010	0.001	1	0.0	0.0	1	6.59	0.13	17	440.15	50.17	13
Anne Arundel	1.08	0.09	8	0.81	0.08	7	0.06	0.01	17	0.049	0.007	14	5.9	2.9	6	7.15	0.05	10	427.26	70.79	15
Baltimore	2.43	0.16	12	2.29	0.16	12	0.03	0.01	8	0.042	0.015	10	0.0	0.0	1	7.65	0.05	2	1368.95	191.54	3
Baltimore City	1.98	0.37	10	1.76	0.35	10	0.03	0.00	6	0.040	0.016	8	23.4	16.8	13	7.66	0.03	1	1393.13	70.64	2
Calvert	0.76	0.14	4	0.61	0.14	5	0.06	0.01	15	0.077	0.012	22	0.0	0.0	1	6.98	0.10	11	558.73	94.79	9
Caroline	6.24	0.43	24	5.51	0.43	24	0.06	0.02	18	0.049	0.006	13	25.6	9.2	14	7.35	0.15	7	550.76	63.29	10
Carroll	3.78	0.32	20	3.42	0.28	20	0.14	0.10	23	0.046	0.019	11	0.0	0.0	1	6.31	0.08	19	163.96	18.92	22
Cecil	2.75	0.25	16	2.40	0.25	14	0.05	0.01	14	0.062	0.011	19	4.6	4.6	4	6.23	0.11	21	195.00	22.34	20
Charles	0.74	0.08	1	0.48	0.06	2	0.07	0.02	20	0.040	0.006	9	7.3	3.1	7	7.28	0.05	8	608.94	55.20	7
Dorchester	5.20	0.68	23	4.59	0.66	23	0.05	0.01	11	0.075	0.019	21	26.1	8.0	15	6.08	0.12	22	198.26	39.09	19
Frederick	2.69	0.26	13	2.43	0.24	15	0.05	0.01	13	0.053	0.010	15	0.0	0.0	1	7.44	0.09	5	905.96	109.14	4
Garrett	0.96	0.08	6	0.86	0.08	8	0.01	0.00	2	0.013	0.001	2	0.0	0.0	1	6.64	0.10	16	177.66	28.08	21
Harford	2.90	0.19	17	2.57	0.18	18	0.02	0.00	5	0.030	0.003	4	3.8	2.1	3	7.16	0.05	9	423.51	26.40	16
Howard	2.72	0.17	14	2.46	0.16	16	0.02	0.00	4	0.037	0.019	6	0.0	0.0	1	7.40	0.07	6	743.83	65.85	6
Kent	3.77	0.58	19	2.97	0.53	19	0.22	0.11	24	0.117	0.020	23	8.2	5.3	9	6.70	0.08	13	465.60	59.77	11
Montgomery	2.30	0.19	11	2.10	0.19	11	0.03	0.01	7	0.027	0.003	3	0.0	0.0	1	7.47	0.08	4	743.93	65.66	5
Prince Georges	0.92	0.07	5	0.61	0.05	4	0.09	0.03	21	0.048	0.005	12	4.9	3.2	5	6.88	0.07	12	592.50	80.51	8
Queen Annes	4.26	0.38	22	3.68	0.36	22	0.06	0.03	19	0.056	0.006	17	3.2	2.8	2	6.65	0.09	15	429.26	41.76	14
Somerset	1.01	0.14	7	0.40	0.12	1	0.05	0.01	12	0.060	0.028	18	38.3	8.5	16	6.53	0.11	18	338.83	80.09	17
St Marys	0.76	0.09	3	0.57	0.09	3	0.04	0.01	9	0.038	0.007	7	12.2	5.7	10	5.21	0.11	24	49.44	12.09	24
Talbot	4.15	0.71	21	3.48	0.71	21	0.04	0.01	10	0.055	0.009	16	22.5	15.9	12	6.67	0.11	14	457.14	48.58	12
Washington	2.74	0.33	15	2.49	0.28	17	0.02	0.01	3	0.037	0.006	5	0.0	0.0	1	7.59	0.10	3	1985.02	241.79	1
Wicomico	3.07	0.29	18	2.40	0.29	13	0.06	0.01	16	0.067	0.017	20	20.3	8.6	11	6.26	0.13	20	222.69	30.33	18
Worchester	1.91	0.41	9	1.35	0.37	9	0.11	0.08	22	0.125	0.049	24	7.6	7.5	8	5.84	0.21	23	163.21	35.16	23

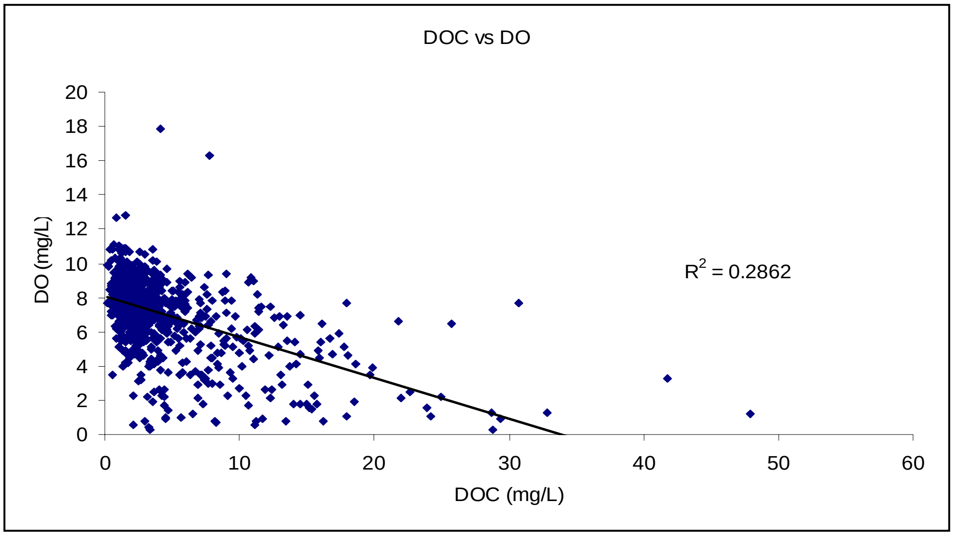


Figure 8-1. Dissolved organic carbon (DOC) levels vs. dissolved oxygen (DO) from the 2000-2004 MBSS

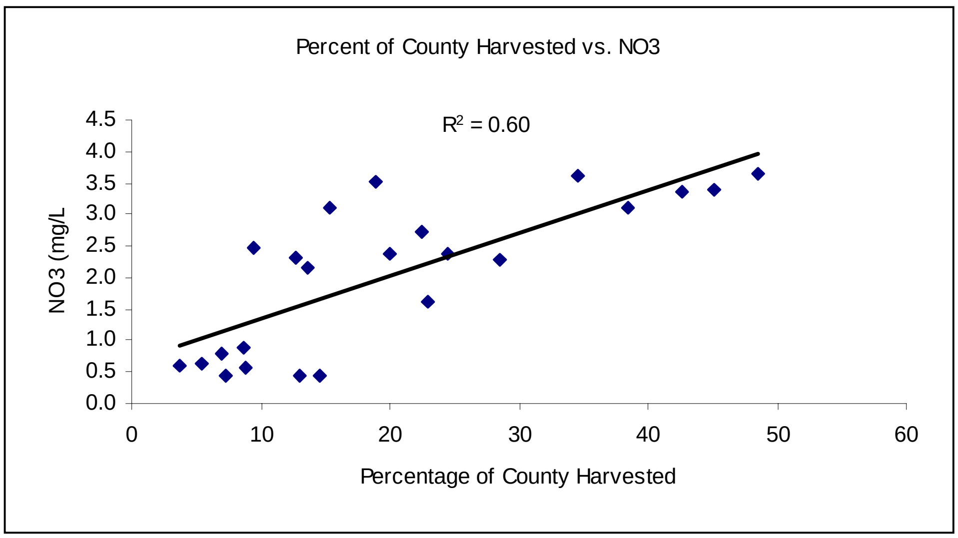


Figure 8-2. Mean nitrate-nitrogen levels from the 2000-2004 MBSS, by county, and the percentage of that county harvested as cropland (crop data from USDA 2002)

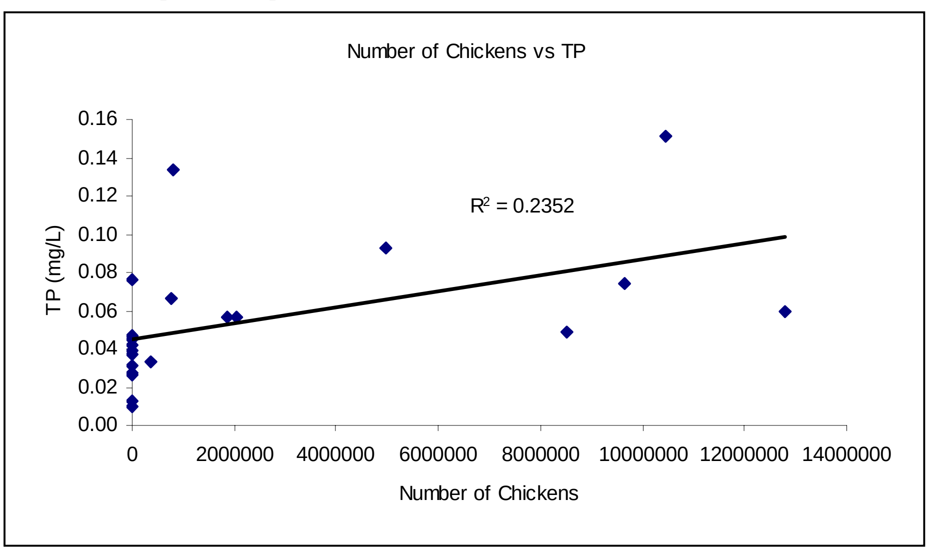


Figure 8-3. Mean Total Phosphorous levels from the 2000-2004 MBSS, by county, and the number of chickens raised in the county (poultry data from USDA 2002)

NATURAL NUTRIENT LEVELS IN MARYLAND STREAMS

A commonly asked question when nutrients in streams are discussed is: what are background or 'natural' levels of nutrient concentration in streams? As essentially all of Maryland has been logged, affected by atmospheric deposition of nitrogen, and otherwise disturbed at one time or another, this question is difficult to answer. However, to gain some insight into this question, all sites in the 1995-2004 dataset with > 90% forest in the upstream catchment were analyzed separately. The mean, median, 90th percentile, and 10th percentile for nitrogen and phosphorus species are shown below, along with chloride, a general indicator of human disturbance. It should be noted that because of the level of human disturbance in many soil types and geologic strata, some areas of Maryland may not be accurately characterized by the information presented. However, as there is a strong trend of decreasing nutrient levels with increases in percent forest in the corresponding watershed, it follows that nutrient levels in old growth, undisturbed forests throughout Maryland would be lower than the best sites that remain today.

Summary of nutrient parameters for MBSS water quality collected during spring baseflow in first through third order streams for all Maryland sites (both rounds) with greater than a 90% forested watershed (units = mg/L).

Parameter	Mean	Median	Lower Quartile	Upper Quartile	10% Percentile	90% Percentile	N
Nitrate-N	0.47	0.31	0.14	0.61	0.06	1.14	187
Nitrite-N	0.0011	0.0004	0.0004	0.001	0.0004	0.0025	107
Ammonia-N	0.012	0.0044	0.0024	0.015	0.002	0.027	114
Total N	0.59	0.46	0.22	0.73	0.12	1.45	134
Total P	0.012	0.008	0.006	0.015	0.004	0.021	134
Ortho-PO_4	0.003	0.0007	0.0007	0.0035	0.0006	0.0078	126
Chloride	5.98	3.04	1.23	6.28	1.01	10.5	134

8.2.2.4 pH and Acid Neutralizing Capacity (ANC)

The streams with the highest mean pH values (uncorrected for log scale) in the state were in Baltimore City (7.66) and Baltimore County (7.65) (Table 8-2). In contrast, the lowest mean values were observed in St. Mary's (5.2) and Worcester (5.84) streams. In terms of buffering capacity against acid inputs, Washington County had the highest mean ANC value (1985 μeq/l), and Somerset County had the lowest mean ANC (49 μeq/l). The generally elevated pH and buffering capacity observed in Baltimore City and County are most likely due to the effects of urbanization, and the low pH and buffering capacity on the lower eastern shore may be due to naturally acidic conditions that have been exacerbated by the continuing effects of acid deposition and the application of nitrogen fertilizer.

Streams with ANC less than 0 μeq/l are acidic and very poorly buffered. Streams with ANC between 0 and 200 μeq/l are only moderately buffered and may periodically have low pH levels during rain or snowmelt events. Those streams with ANC greater than 200 μeq/l are well-buffered.

8.2.3 Physical Conditions

8.2.3.1 Overall Conditions

Physical conditions play a key role in determining stream health. To provide an overall indication of stream habitat quality, the MBSS developed a multi-metric Physical Habitat Index (PHI). As with the Indices of Biotic Integrity for fish and benthic macroinvertebrates, the PHI was developed using a set of defined reference and degraded conditions and an independent set of data was used for validation purposes. Specific components of the index vary by region, but the core metrics include remoteness, epifaunal substrate, bank stability, and shading.

Of all Maryland counties and Baltimore City, Allegany and Garrett counties had the highest mean PHI values (77 on a 100 point scale) during 2000-2004 (Table 8-3). In contrast, Baltimore City (50/100) and Cecil County (63/100) had the lowest mean habitat values in the state during that timeframe.

Table 8-3. Mean values for key physical attributes of 4th order and smaller Maryland streams, by county, based on results from the 2000-2004 MBSS

	Physical Habitat Index (PHI)			Channelized[1]			Trash Rating			Bank Erosion			Riparian Buffer			Riparian Buffer Breaks		
COUNTY	**Mean Score (0-100)**	**SE**	**Rank**	**% Stream miles**	**SE**	**Rank**	**Mean Score (0-20)**	**SE**	**Rank**	**% Stream miles Optimal[2]**	**SE**	**Rank**	**% Stream miles no buffer**	**SE**	**Rank**	**% Stream miles with Severe Buffer Breaks[3]**	**SE**	**Break Rank**
Allegany	76.52	1.77	2	17.2	4.3	11	16.3	0.5	14	88.0	3.8	3	6.6	2.8	14	3.8	2.0	3
Anne Arundel	68.39	1.91	16	19.9	4.8	13	11.9	0.7	3	30.5	6.9	22	2.7	1.7	10	12.4	4.8	17
Baltimore	64.34	1.90	22	21.8	5.5	15	12.9	0.6	4	25.5	5.9	23	7.8	3.9	17	14.6	4.8	21
Baltimore City	50.21	2.31	24	40.5	15.0	18	5.2	1.8	1	81.2	13.2	6	9.3	9.2	19	43.8	14.6	24
Calvert	66.85	3.74	21	9.0	9.0	3	16.4	1.0	16	41.0	13.9	16	0.0	0.0	1	9.0	9.0	13
Caroline	70.90	1.55	8	58.3	9.0	22	16.6	0.6	19	73.0	10.4	9	2.1	2.0	8	4.2	4.1	4
Carroll	69.38	1.54	12	13.1	5.4	6	16.2	0.3	13	34.7	9.2	20	10.0	4.1	20	10.5	4.1	15
Cecil	62.82	2.34	23	14.2	6.9	8	14.3	0.6	7	42.2	8.6	15	11.2	6.2	22	5.4	3.6	6
Charles	75.67	1.18	3	10.5	3.8	4	16.3	0.4	15	57.1	5.5	12	0.0	0.0	2	0.9	0.9	2
Dorchester	69.06	2.18	14	57.1	10.1	21	16.5	0.8	17	82.4	8.2	5	0.0	0.0	3	10.3	5.4	14
Frederick	70.37	2.00	11	14.6	5.2	9	15.6	0.5	10	62.7	7.2	11	11.1	4.2	21	12.8	5.0	18
Garrett	77.02	1.86	1	6.6	2.8	2	17.6	0.3	24	88.9	4.2	1	7.7	3.4	15	7.4	3.3	12
Harford	68.26	1.33	17	18.8	3.9	12	13.0	0.4	5	55.5	5.5	13	5.9	2.5	13	6.7	2.8	10
Howard	71.52	1.79	6	16.5	5.5	10	14.4	0.5	8	19.5	5.5	24	4.8	3.4	11	6.8	4.0	11
Kent	67.80	2.14	18	11.2	8.0	5	16.9	0.5	21	38.1	8.2	17	1.2	1.2	7	6.6	6.6	9
Montgomery	70.75	1.17	9	21.6	5.2	14	13.8	0.5	6	35.3	6.6	19	7.7	3.6	16	10.5	4.1	16
Prince Georges	67.41	1.88	20	31.4	5.6	16	10.9	0.6	2	51.9	7.1	14	2.1	2.1	9	13.5	4.0	19
Queen Annes	67.45	2.66	19	43.1	10.7	19	17.1	0.4	23	64.5	11.4	10	0.0	0.0	4	4.5	4.5	5
Somerset	70.57	1.86	10	95.5	4.5	24	16.6	0.5	18	84.3	7.9	4	5.4	5.4	12	5.4	5.4	7
St Marys	72.41	1.82	5	3.9	2.9	1	16.2	0.6	12	36.3	9.2	18	1.0	1.0	6	5.5	3.7	8
Talbot	71.29	1.84	7	33.6	19.3	17	16.0	0.5	11	33.7	11.3	21	0.0	0.0	5	0.0	0.0	1
Washington	69.33	2.51	13	13.2	5.1	7	16.6	0.4	20	77.0	6.7	8	20.1	6.0	24	13.5	4.3	20
Wicomico	72.67	2.21	4	52.1	10.0	20	14.6	0.8	9	88.0	6.6	2	19.2	7.0	23	19.2	7.0	23
Worchester	68.91	1.73	15	67.9	9.4	23	17.0	0.6	22	77.4	9.6	7	9.0	5.0	18	14.8	5.4	22

1 Estimate based only on sites that were completely channelized

2 Optimal bank erosion defined as bank erosion ≥16 on a 16-20 scale.

3 Estimate based on 75m sites that had discontinuity in the riparian buffer that was judged to have a significant negative impact on the stream during storm events or baseflow conditions (e.g., raw sewage entry)

8.2.3.2 Trash

Human refuse in and along streams is unsightly but may have little influence on chemical and physical conditions. However, trash along streams is an indication that other, more toxic contaminants such as oil and antifreeze have been dumped. As would be expected, urban counties had lower trash rating scores than agricultural counties (Table 8-3). Baltimore City received the lowest mean rating (5 on a 20 point scale with lower scores indicating more trash), followed by Prince George's, Anne Arundel, and Baltimore counties. The least amount of human refuse on average along or in streams was found in Garrett (18/20) and Somerset counties (17/20).

8.2.3.3 Channelization

In Maryland, stream channels are moved and/or hardened for a number of reasons, including rapid routing of flood waters, protection of property and transporation infrastructure, and lowering of water tables to facilitate the use of land for agriculture. Unfortunately, channelized streams have reduced habitat quality and are less able to retain suspended sediments and retain and process nutrients. The ultimate result is movement of sediment and excess nutrients into estuaries such as Chesapeake Bay, where they cause 'dead zones' that are devoid or depleted of dissolved oxygen and degraded habitats for submerged aquatic vegetation. Dead zones, in turn cause significant damage to commercial and recreational fisheries. During the 2000-2004 MBSS, the estimated percent of non-tidal stream miles that were channelized varied from 4% in St. Mary's County to 96% in Somerset County (Table 8-3). Channelization was also a dominant stream feature in two other Eastern Shore counties: Worcester (68%) and Dorchester (57%). Among the counties with substantial urban land use, channelization varied from 20% in Anne Arundel County to 41% in Baltimore City.

Among various types of channelization, only ditches were found in more than 50% of the stream miles in a county (Table 8-4). This occurred in Somerset (96%), Worcester (65%), Caroline (58%), and Dorchester (54%) counties. Only four counties and Baltimore City had no ditched streams. In contrast, concrete channels were most extensive in more urban jurisdictions. Baltimore City had an estimated 28% of stream miles in concrete, followed by Baltimore County (11%), Prince George's (9%), and Montgomery (6%). Concrete channels provide exceptionally poor habitat for stream organisms, do not dissipate energy, and route water rapidly downstream, exacerbating flooding.

Table 8-4. Estimates of channelization types (as percent of stream miles) by county based on the 2000-2004 MBSS

County	Concrete	Ditched	Gabion	Pipe	RipRap	None
Allegany	4.6	1.3	1.1	3.4	4.3	85.3
Anne Arundel	2.5	4.8	1.2	0.0	7.8	83.8
Baltimore	11.1	0.7	2.1	0.6	7.3	78.2
Baltimore City	28.0	0.0	6.3	0.0	6.3	59.5
Calvert	0.0	9.0	0.0	0.0	0.0	91.0
Caroline	0.0	58.3	0.0	0.0	0.0	41.7
Carroll	0.6	8.1	0.0	3.3	1.1	86.9
Cecil	2.6	0.0	0.0	2.6	9.0	85.8
Charles	0.0	5.0	0.0	4.8	0.6	89.5
Dorchester	0.0	53.8	0.0	0.0	0.0	46.2
Frederick	0.0	0.0	2.9	5.8	5.9	85.4
Garrett	1.4	0.0	1.2	1.5	2.5	93.4
Harford	3.2	7.7	0.0	2.6	5.3	81.2
Howard	1.6	2.6	0.0	4.5	7.8	83.5
Kent	6.4	4.7	0.0	0.0	0.0	88.8
Montgomery	5.8	0.0	0.0	2.0	13.9	78.3
Prince Georges	8.9	10.4	1.1	1.8	9.3	68.6
Queen Annes	4.5	36.0	0.0	2.6	0.0	56.9
Somerset	0.0	95.5	0.0	0.0	0.0	4.5
St Marys	0.0	3.9	0.0	0.0	0.0	96.1
Talbot	0.0	22.5	0.0	0.0	0.0	77.5
Washington	4.9	0.8	0.0	4.3	3.2	86.8
Wicomico	0.0	42.5	3.8	5.9	0.0	47.9
Worchester	0.0	65.0	0.0	0.0	0.0	35.0

Gabions, or rock-filled baskets, were much less extensive than either concrete channels or ditches. Baltimore City had the highest percentage of stream miles with gabions (6%), and only 7 of 23 Maryland counties and Baltimore City had gabions in any of their randomly selected MBSS sites. Rip-rap, in contrast, was most common in Montgomery County (14% of stream miles) and was documented in 14 of the 24 jurisdictions. Piped culverts were most common at MBSS sites in Wicomico and Frederick counties (6% of stream miles in each), but culverts occur throughout the state and are the most commonly used method of passing streams under roads.

8.2.3.4 Bank Erosion

Excessively eroded banks are a symptom of watershed-scale problems such as impervious surface-related runoff, unwise harvest of riparian vegetation, and stream elevation changes from improper culvert installation. The 2000-2004 MBSS data indicate that Howard County had the lowest percentage of stream miles with little to no evidence of bank erosion (20%). Other counties with relatively few intact stream banks included: Baltimore City (26%), Baltimore (31%), and Talbot (34%; Table 8-3). In contrast, nearly 90% of stream banks were rated as optimal for minimal bank erosion in Garrett, Allegany, and Wicomico counties.

8.2.4 Riparian Conditions

Riparian buffers play a key role in providing instream habitat, temperature control, organic matter inputs, and energy dispersal during storm events. In addition, they also filter excess nutrients and other contaminants before they reach the stream. Among all counties in Maryland, Washington County had the highest estimate of stream miles with no riparian buffers (20%), followed by Wicomico (19%), Cecil (11%) and Frederick (11%; Table 8-3). In contrast, no bufferless stream sites were observed in Calvert, Charles, Queen Anne's, Dorchester, and Talbot counties.

In cases where breaks in riparian buffers exist, the beneficial aspects of buffers can be greatly reduced or virtually eliminated. For the MBSS, breaks in the riparian buffer zone were defined as any short-circuiting of the existing vegetation that allowed water, sediment, or potential contaminants to flow directly into the stream without passing through or over a buffered area. Breaks were rated as minor or severe, and types included storm and tile drains, impervious surfaces and erosion gullies, crops, orchards and pastures, and roads and railroads. Of the counties with no totally unbuffered sites, all counties but Talbot had sites with severe breaks in existing buffers (Table 8-3). Other counties with less than 5% of stream miles with severe buffer breaks included: Allegany, Caroline, Charles, Kent, and Queen Anne's. Counties with the highest occurrence of buffer breaks were Baltimore City (44%), Worcester (20%), Wicomico (15%), and Baltimore counties (15%). From these analyses, it is clear that buffer breaks are a potentially important limitation to the effectiveness of riparian buffers in protecting Maryland streams.

8.2.5 County Stressors

Identifying stressors is critical to the development of management actions by counties to restore and protect streams. In particular, counties have a key role in implementing Total Maximum Daily Loads (TMDLs) developed by the State to address streams impaired under Section 303(d) of the Clean Water Act. Counties are also key partners in active restoration programs for Maryland's streams, such as Maryland's Watershed Restoration Action Strategies (WRASs) and Chesapeake Bay Program Tributary Strategies. Although TMDL development and other activities rely on the identification of specific causes of degradation to guide actions, unless relevant information is available to reliably identify these stressors, funding, effort and political capital could be spent on problems that are not really prevalent at the watershed scale.

Merely identifying stressors, however, is still not sufficient to guide effective management actions for Maryland streams. Counties and other natural resource stewards must assess the relative degree of risk posed by different stressors at site, watershed, and regional scales. Only by comparing these risks and determining the cumulative impacts that are likely to result, can an effective stream restoration and protection strategy be implemented. To fully assess the threat from an individual stressor, the importance (or severity) and the prevalence (or extent) of the stressor must be known. The severity of each stressor was assessed based on the response of fish and benthic macroinvertebrate Indices of Biotic Integrity (IBI) scores to established thresholds.

Streams and their inhabitants are subject to myriad stressors, some of which may be nearly impossible to measure, co-occur with other stressors, or otherwise difficult to assess. To contribute to what is known about stressors and biological responses in Maryland, a total of ten stressors were identified from MBSS data and landscape-level data (see sidebar). For each stressor, the proportion of MBSS sites having poor fish or benthic IBI scores when the threshold for degradation was exceeded was divided by the proportion of sites with poor IBI scores, given stressor scores below the threshold for degradation (Figure 8-4). Applying this technique to stressors measured as part of the MBSS, the stressor that caused the greatest difference in IBI scores above and below the threshold was Acid Mine Drainage. By incorporating both severity and extent into stressor analysis, important insight can be gained as to which

Identifying stressors is critical to meeting Clean Water Act mandates and developing management actions that can restore or protect the desired condition of streams. Stressor identification, or the diagnosis of stream problems, is an emerging field that draws on the approaches of traditional risk assessment while using new metrics derived from more sophisticated monitoring data. Therefore, the MBSS is conducting analyses in this and other volumes to investigate which stressors are responsible for degradation of Maryland streams.

Stressors can be organized according to the five major determinants of biological integrity in aquatic ecosystems: water chemistry, energy source, habitat structure, flow regime, and biotic interactions. Water chemistry comprises acidity, dissolved oxygen, and contaminants. Energy source describes the size, abundance, and nutritional quality of food from both primary production and allochthonous inputs. Habitat structure encompasses physical features such as water depth, current velocity, substrate composition, and morphology of the stream channel. Flow regime refers to seasonal, annual, and altered patterns in water quantity and delivery. Biotic interactions include competition, predation, and parasitism, from both native and introduced species. The MBSS directly measures many of these stressors and ancillary information, such as land use, can be used to evaluate others. Some stressors, such as pesticides, currently are not considered in MBSS analyses. This volume includes analysis of ten stressors affecting Maryland streams: invasive fish and mussels, invasive plants, bank stability, acid mine drainage, acidic deposition, dissolved oxygen, high nitrate-nitrogen, channelization, no riparian buffer, and urban land use (see below). These 10 stressors are meant to be a representative but incomplete list. The thresholds of concern for each stressor were selected based on expert consensus and analyses to date on the MBSS data. In particular, stressor values that result in demonstratively lower fish or benthic IBI scores have been used as thresholds. Additional stressor analyses are being conducted with the MBSS data and thresholds may be revised in the future.

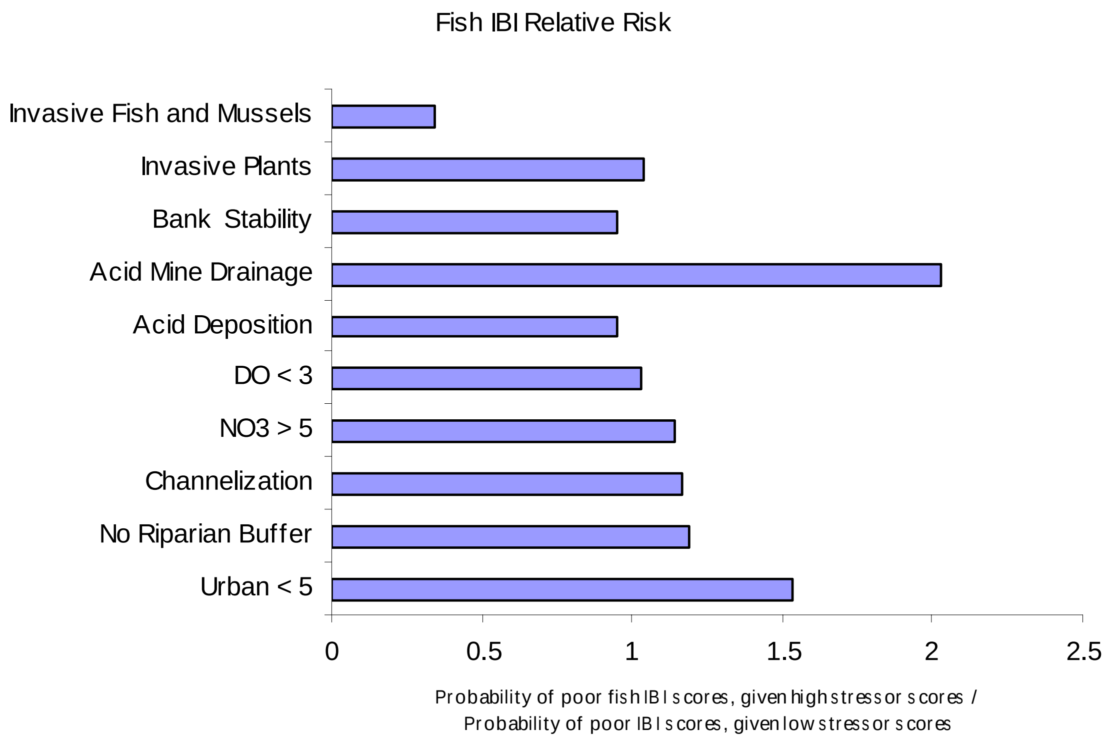
LIST OF STRESSORS AND THRESHOLDS USED IN THE 2000-2004 MBSS:

Urban	> 5%	Dissolved Oxygen	< 3 mg/L
Bank Stabling	Poor or Very Poor	Acid Mine Drainage	Present
Channelization	Present	Acid Deposition	Present
Riparian Buffer	0 m	Invasive Plants	Present
Nitrate-Nitrogen	> 5mg/L	Non-Native Aquatic Species (Fish or Bivalves)	Present

stressors have the strongest effect on streams statewide or within a county or watershed.

Because the MBSS sampling design is probability-based, the extent of any stressor that is measured can be estimated with a known degree of confidence. To determine the extent of each stressor in each county and Baltimore City, we estimated the percentage of stream miles with stressor scores above the threshold of degradation. Based on these estimates, the single most prevalent stressor affecting Maryland streams was the presence of non-native invasive plants (Figure 8-5). This stressor was present in 100% of stream miles for Baltimore, Cecil, Carroll, Howard, and Montgomery counties, and high in many other counties as well. Of the other stressors characterized by the MBSS, urban influence was greatest in Baltimore City and Anne Arundel County, while unstable banks were most extensive in Howard and Talbot counties. Channelization was most extensive in Somerset and Worcester county streams, and Washington County had the most stream miles with no riparian buffer. Deleterious nitrate-nitrogen levels were most frequent in Caroline and Dorchester county streams, while low dissolved oxygen was most extensive in Somerset County. Acid Mine Drainage existed only in Allegany and Garrett Counties, while acid deposition effects were much more widespread and most extensive in St. Mary's and Garrett counties. And finally, non-native aquatic animals, including fish, occurred extensively in all Maryland counties but were most prevalent in Howard and Kent counties.

The extent of each stressor, combined with the severity estimate, provides useful information about the relative risk each stressor poses to streams within areas of interest such as counties. A more complete discussion of stressors and their relative risks to Maryland streams is found in: 2000-2004 Maryland Biological Stream Survey Volume 14: Stressors (http:www/dnr/Maryland.gov/streams/pubs/ea05-11_biodiv.pdf).



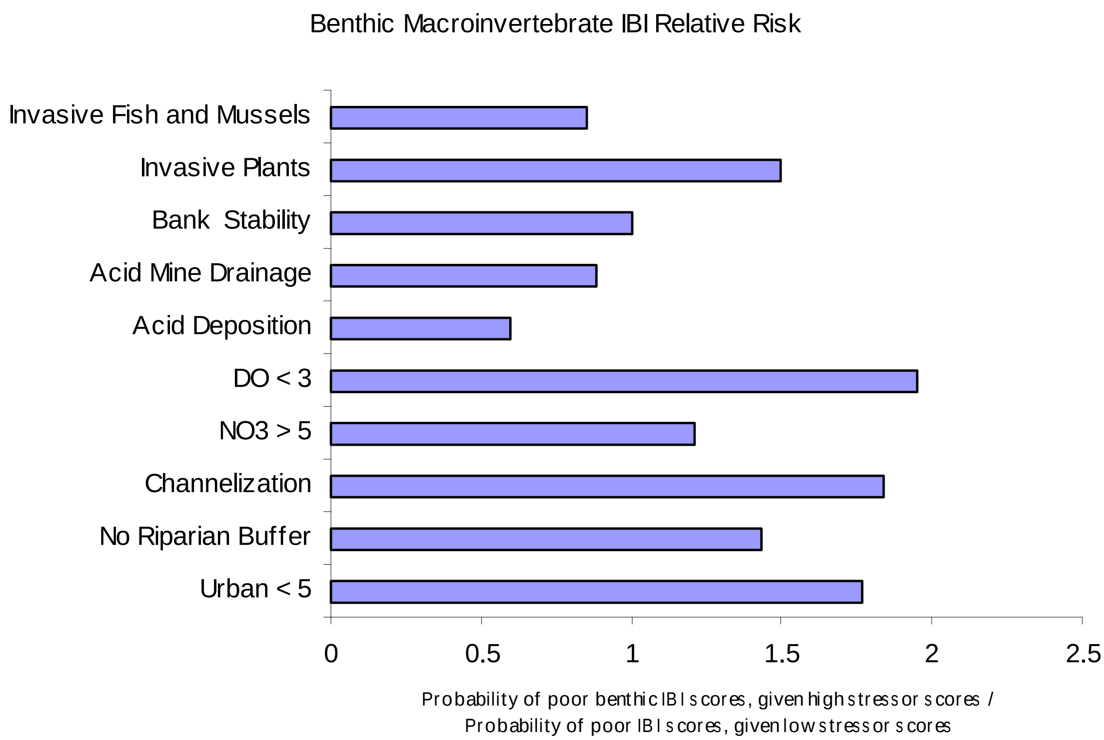


Figure 8-4. Relative severity of stressors affecting biota in Maryland streams, based on 2000-2004 MBSS data

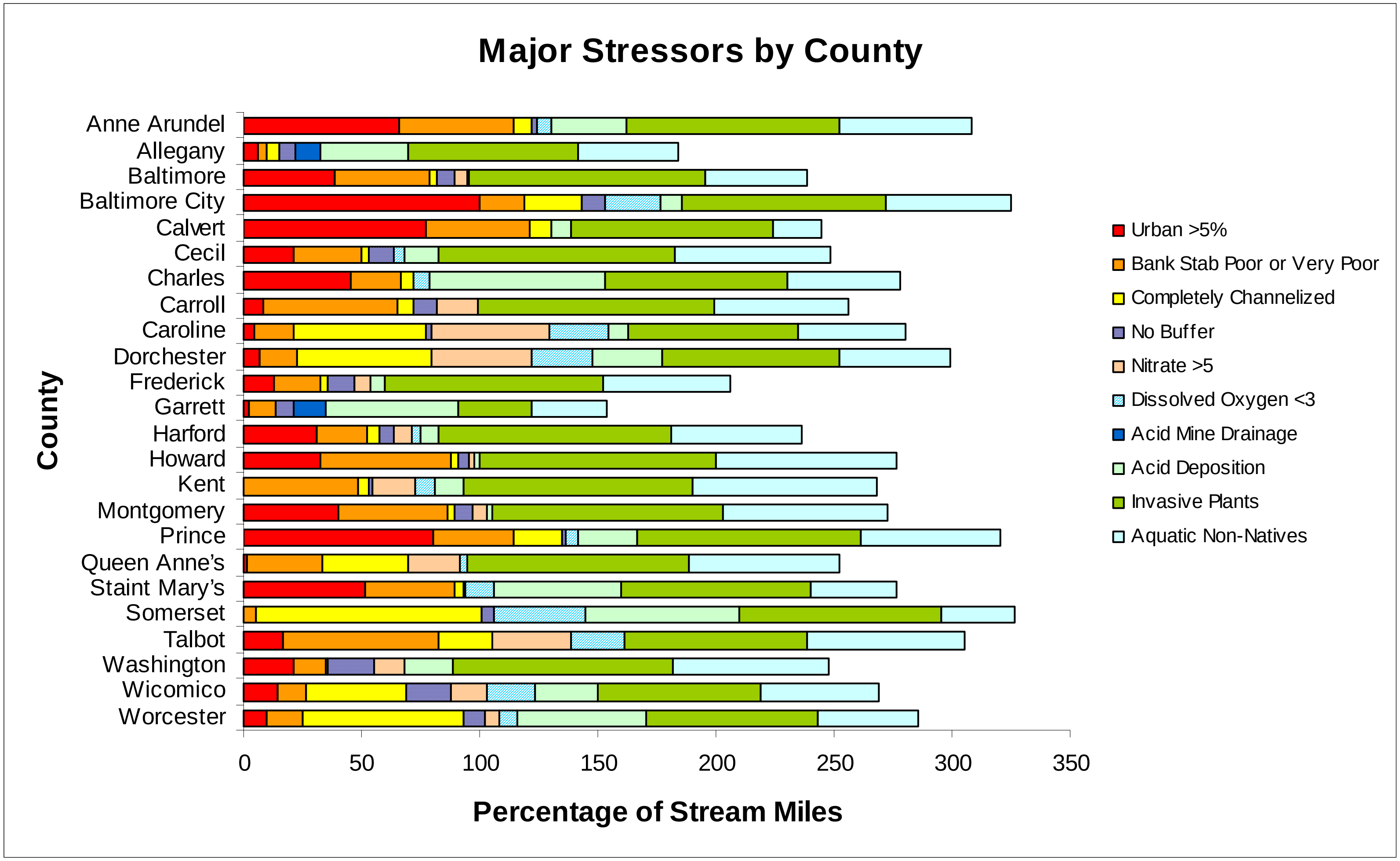


Figure 8-5. Stressors by county, in percent of total stream miles for that county, based on the 2000-2004 MBSS. Values will be greater than 100% because multiple stressors can impact the same stream reach